VOLUME 78 SEPARATE No. D-102

PROCEEDINGS

AMERICAN SOCIETY OF CIVIL ENGINEERS

DECEMBER, 1952

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

DISCUSSION OF UTILIZATION OF GROUND WATER IN CALIFORNIA

(Published in November, 1951)

By Dean C. Muckel, and T. Russel Simpson

IRRIGATION AND DRAINAGE DIVISION

Headquarters of the Society
33 W. 39th St.
New York 18, N.Y.

PRICE $0.50 PER COPY

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DISCUSSION

Dean C. Muckel[3].—The reader of this paper will be impressed by the fact that information and data exist for a complete analysis of the ground-water situation in the State of California. Credit is due to the agencies and individuals responsible for collecting basic data and making pertinent investigations over periods of many years. The author has made a brief, concise accounting of the ground-water supply, and suggests the ultimate development possible.

Each of the seven major hydrographic areas used by the author contain numerous surface drainage areas, ground-water basins, and subbasins. Some of these basins are interconnected in such a manner that extractions or replenishments in one will eventually affect adjacent basins within the same hydrographic area. In many cases, however, there is no connection between basins, and the hydrographic areas as delineated will function not as a unit but as a group of individual units each with its own characteristics.

Several ground-water reservoirs are discussed with relation to the expected ground-water development. Since most of the development has come about by the extraction of water through wells located without any basin-wide consideration or control, future development will probably follow the same lines. Under this system of development, a ground-water basin by concentrations of wells, by unequal replenishment throughout the basin, or by a combination of both, may have conditions of overdraft in one part of the basin and have surpluses and wastes at the same time in other parts of the basin. To obtain the ultimate development, then, each ground-water basin must be given detailed study, and the proper location of the extractions planned as well as the total quantities of water to be removed by pumping.

In the southern San Joaquin Valley the full utilization of the underground storage depends partly on the success or failure of spreading imported water for artificial replenishment. Although spreading has been carried on successfully in certain areas (notably the South Coastal Basin of California), conditions in the southern San Joaquin Valley do not generally lend themselves to spreading. The prevailing soils are fine-textured with low rates of percolation. In some places hardpans, clay pans, and other impervious or nearly impervious strata retard the deep percolation of water applied to the surface. There are now (1952) plans in the San Joaquin Valley to spread water on soils classified as loams and fine sandy loams underlain in places by lenses of hardpan. The natural rates of percolation are low—less than 1 acre-ft per acre per day and decreasing with the time of submergence. The writer has been participating in attempts to improve the natural rates of percolation, which have been successful on small test ponds. (Joint investigation with the Soil Conservation Service (Research) U. S. Department of Agriculture; U. S. Bureau of Reclamation; North Kern Water Storage District; California State Division of

Note.—This paper by T. Russel Simpson was published in November, 1951, as *Proceedings-Separate No. 102.* The numbering of footnotes in this Separate is a continuation of the consecutive numbering used in the original paper.

[3] Irrig. Engr., Div. of Irrig. Eng. and Water Conservation (Soil Conservation Service), Research, U. S. Dept. of Agri., Berkeley, Calif.

Water Resources; and California Agricultural Experiment Station, participating.) Although no opportunity has presented itself as yet to carry the trials to large-scale spreading, it is obvious that successful spreading on these soils will require careful planning and study and the expenditure of large sums of money for land, construction of spreading systems, and possibly for soil treatments and management.

Although the author has treated the southern San Joaquin Valley as a single underground reservoir, it functions more or less as a series of subbasins because of heavy pumping concentrations and unequal natural replenishment throughout the area. Artificial replenishment by spreading, therefore, requires that spreading systems be located in the intake areas of that part of the ground-water basin or reservoir needing replenishment and having underground storage space. The location of spreading systems requires careful investigation, as misplaced systems might feasibly cause more damage than good by creating perched water table resulting in unfavorable drainage conditions.

The author obviously did not intend to enter into a detailed analysis of the various ground-water basins and their individual complexities. The foregoing comments are offered to emphasize the fact that ultimate development of any underground reservoir requires considerably more study and analysis than is involved in an inflow-outflow equation on a basin-wide basis.

T. Russel Simpson,[4] M. ASCE.—Several separate ground-water units that exist in each of the seven major hydrographic areas in California are mentioned by Mr. Muckel. Comprehensive ground-water investigations have been made under the writer's direction in four of the hydrographic areas covering about 2,000,000 acres in twenty-seven units during the 6-yr period, 1945–1950. Ground-water overdrafts either have occurred in these units or threaten to occur in the near future. Mr. Muckel has been doing excellent laboratory and field research with the objective of stimulating additional ground-water recharge through artificial percolation by spreading. Results of the research will be helpful in solving ground-water problems.

It was not intended to enter into a detailed analysis of the various ground-water units and their individual complexities because such a discussion would be quite extensive. It may be of interest to summarize the types of basic data collected in the aforementioned comprehensive ground-water investigations in order to provide information for making a detailed analysis:

(*a*) Establish supplemental precipitation stations to obtain precipitation records well-distributed over the ground-water basin for evaluation of weighted average annual precipitation from isohyets or by the Thiessen polygon method.

(*b*) Install supplemental stream-gaging stations to obtain complete data on surface inflow to, and outflow from, the ground-water basin.

(*c*) Collect all available well-driller logs, and drill such test wells as are needed where logs are not available, to give good coverage on valley fill.

(*d*) Make a general geologic study of valley fill from well-log groups to obtain probable specific yields at various depth ranges from ground surface down to desirable maximum pumping lifts; make a peg model and delimit

[4] Cons. Engr.; Prof. of Irrig. Eng., Univ. of California, Berkeley, Calif.

probable zones of confined or partly confined aquifers from the geologic study and from ground-water behavior during recharge and discharge.

(*e*) Collect all antecedent information on ground-water levels, pumping records, water analyses, and cultural surveys; obtain annual records of agricultural power sales back through the base-period, and all pump test records during the past 3 years; obtain such other information as may be useful in estimating the historic use of water and the crop pattern.

(*f*) Select test tracts of all crops generally grown in the area on various soil textures using usual methods of irrigation, and obtain detailed records of water use under average practices throughout the period of investigation. Have pump tests made and determine the irrigation efficiency of all test tracts; also collect pump test records made during the investigation elsewhere in the ground-water basin.

(*g*) Develop information from which consumptive use of all types of water-consuming areas can be estimated by the available heat method or the irrigation efficiency method.

(*h*) Select a grid of measuring wells, spaced about ¾ mile apart over the ground-water basin, from existing wells supplemented with jettied test wells where required. Water levels should be measured at all wells under as nearly static conditions as possible after the close of the season of heavy draft, and again after the season of recharge. Use about 10% of the measuring wells as control wells for monthly water level measurements (oftener if indicated) during the investigation.

(*i*) Make an annual comprehensive cultural survey during the period of investigation, from aerial photos transferred to the United States Geological Survey base. Classify culture into equal water-consuming groups and determine acreage by map cutting-and-weighing method.

(*j*) Collect water samples from all operating wells and make field analyses for total mineral solubles and chlorides. Make complete analyses on about 10% of the samples. If unusal concentrations of mineral solubles are found from field tests, make such complete analyses in the zone of pollution as to identify extent, type, and source of pollution.

(*k*) Make a land classification and soil survey, if not included in antecedent information.

(*l*) Use one of the direct methods developed to determine subsurface inflow, subsurface outflow, and safe ground-water yield, where applicable.[5,6,2,7,8]

(*m*) Locate areas of overdraft and near-by sources of surplus water. Develop feasible plans for development of supplemental water to meet present and probable ultimate needs—in successive steps or phases if possible—and determine the cost of such supplemental water.

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[5] "Utilization of Ground-Water Storage in Stream System Development," by Harold Conkling, *Transactions*, ASCE, Vol. 111, 1946, p. 275.

[6] Discussion by Raymond A. Hill of "Utilization of Ground-Water Storage in Stream System Development," by Harold Conkling, *ibid.*, p. 306.

[2] "Salinas Basin Investigation," by T. Russel Simpson, *Bulletin No. 52*, Div. of Water Resources, Dept. of Public Works, State of California, Sacramento, Calif., 1946.

[7] "Ground Water," by C. F. Tolman, McGraw-Hill Book Co., Inc., New York, N. Y., 1937, pp. 490-491.

[8] "Water Resources of Southern San Joaquin Valley," by S. T. Harding, *Bulletin, No. 11*, California Div. of Eng. and Irrig. and Water Rights, Documents Section Printing Div., State of California, Sacramento, Calif., 1937.

The supply of water to a ground-water unit must balance its disposal during any specified time. Separate evaluation should be made of each item included in total water supply and its disposal during the base-period selected for analysis. After inserting all items in supply and disposal, if the totals are out of balance within the limit of accuracy of the total basic data involved, individual items must be adjusted in accordance with relative probable error to effect closure. Further investigation is indicated if the discrepancy exceeds the limit of accuracy of total basic data.

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